CHAPTER TWELVE
SUBSIDENCE AND EROSION

SUBSIDENCE

Subsidence is a sinking of the land surface. The major cause of subsidence in the Galveston Bay area has been removal of oil, gas, groundwater or other pressurizing substances from the ground, causing the clays to collapse and compact. Because the clays are inelastic, the loss of elevation due to subsidence is permanent. In the Harris/Galveston area subsidence became a serious problem in the 1950s when demand for groundwater increased significantly due to rapid industrial and metropolitan growth in coastal areas. At this time, nearly all water supplies were obtained from groundwater. Billions of gallons were pumped easily and cheaply from industrial and municipal wells accessing the Chicot and Evangeline aquifers.

Although the first surface water supplies became available from Lake Houston and the San Jacinto River in 1954, transmission from these sources was limited and expensive. In the absence of regulation and feasible alternatives, the aquifers continued to be the principal source of water supply until the 1980s.

Significant subsidence persisted until 1987 and resulted in increased flooding and even submergence of coastal lowlands. The most serious loss occurred in the communities lining the Houston Ship Channel where subsidence of up to 10 feet threatened multi-million dollar industries (and the cities built around those industries) with significant economic and property loss. By 1974, the cost of property damage in the Houston-Baytown area caused by subsidence was estimated to be $113 million. Low lying petrochemical plants built on the waterfront of the channel and in Texas City were threatened with permanent inundation as were the people who lived and worked in the area. Subsidence in the Houston-Galveston area has exceeded 1 1/2 feet in an area 70 miles across, 8 feet in several areas surrounding the bay and as much as 10 feet in isolated areas. In 1979, the bay had approximately 600 square miles girded by 285 square miles of marshland; due to subsidence and shoreline erosion, it is projected that by 2010 the bay will be 145 square miles larger with concomitant loss of marshland.

Subsidence also exposes shores to greater wave activity as well as allowing water to come up higher on the coastal banks, contributing in turn to increased erosion rates. Other subsidence-related problems included storm sewer systems that flowed in the wrong direction, and structural damage from the activation of faults. (There are approximately 1000 miles of faultline in the Houston/Galveston area). Faulting can result in a myriad of hazards from pipeline breaks that release toxic chemicals to damage to sophisticated electronic infrastructures, such as that of the Johnson Space Center. For these reasons, initial efforts to arrest subsidence focused on coastal areas southeast of Houston.

REGULATORY FRAMEWORK

The economic consequences of wide scale flooding was the primary catalyst for enacting legislation to curb subsidence. House Bill 552, passed in 1975, is the only legislation addressing subsidence issues in the Houston/Galveston area. In short, the law regulates one source of subsidence (groundwater removal) and targets the largest groundwater users: industry, farmers, and cities. Key language in the act establishes a relationship between subsidence and coastal flooding, and attributes subsidence to the withdrawal of groundwater. Most importantly, the act establishes a separate, self-sustaining agency, the Harris/Galveston Coastal Subsidence District (HGCSD), to monitor groundwater removal in Harris and Galveston Counties, and mandates this agency to devise a regional plan that will not only reduce groundwater use but provide for alternative water supplies.

Although it has been argued that the removal of oil and gas is also a principal cause of subsidence, the act makes no attempt to regulate this process. Officials charged with regulating subsidence in the Houston/Galveston area argue that oil-bearing clays and sands in the region are so deep that the extraction of oil and gas has a negligible effect on subsidence. These officials were not aware of any subsidence due to oil and gas extraction. Moreover, all issues related to oil and gas extraction are within the regulatory purview of the powerful Railroad Commission, and legislators may have been reluctant to challenge RRC jurisdiction over these issues. Finally, legislators may have feared a backlash from the oil and gas industry for double regulation of both groundwater and oil.

Private, residential groundwater wells (also a cause of subsidence) are not addressed in the law either. In fact, wells that are less than 5 inches in diameter escape regulation altogether. Thousands of these wells exist throughout the district. They are currently not considered a problem but could become one were there a sudden increase in population.

IMPLEMENTATION

Implementation of H.B. 552 is carried out under the Regulatory Action Plan written by the Harris/Galveston Coastal Subsidence District. The HGCSD is considered a local government agency authorized to regulate the withdrawal of groundwater within Harris and Galveston Counties for the purpose of controlling subsidence. It is not a state agency but a political entity directly responsible to the legislature. Funding for operations is provided by collecting fees in exchange for issuing permits for water wells. HGCSD has a 17 member board of directors appointed by local government. The board meets once a month.

The Action Plan

This plan divides the district into regulatory areas and establishes objectives and requirements for each. In recent years, objectives in this plan have been based on evaluation of data provided by a computer modeling system, a well data base, data collected from 13 subsidence monitors in Harris and Galveston counties, and the

results of regional releveling programs. The computer modeling program predicts subsidence levels under different regulatory scenarios in order to better assist the District Board in setting the limits now in the plan. The District Plan adopts a long term, phased regulatory approach to arresting subsidence. Enforcement efforts focus on the most acutely affected areas of the district instead of the entire district. The 1992 plan, for example, sets goals through the year 2020 and focuses on areas west of Houston, whereas the last District Plan set goals through 1989 and focused on subsidence in the southeast. The permitting process is considered to be the actual implementation of the plan's regulations.

The HGCSD Regional Plan divides Harris and Galveston counties into regulatory areas with boundaries that are subject to change over time. The areas are based on a commonality of regulatory interests and goals as well as economic and technical considerations. For example, the 1992 plan changed the boundaries of the regulatory areas based on surface water availability, geophysical characteristics, and areas of high groundwater demand. Private property laws prohibit the HGCSD from allocating specific amounts of groundwater to each area. Instead, each area is required to reduce groundwater withdrawal to a certain percentage of total water use within an assigned timeline. The percentage reduction takes surface water availability and other factors into account, and thus varies from one area to the next.

Because the area-wide reduction plan is based on a percentage of *total* groundwater use, the system actually allows for an overall increase in groundwater removal. To compensate for this loophole, the HGCSD establishes a schedule for surface water conversion for each of the areas. In addition, each permittee within a given area must reduce groundwater usage and pledge to convert to a surface water system within a timeline agreed upon by the HGCSD and the permittee. Other conditions for securing or renewing a permit include a statement justifying the amount of water pumped and, in some cases, a water conservation plan. Also, if surface water supply is inadequate to compensate for groundwater loss, total water demand must decrease. The options available to reduce total water demand are limiting growth and implementing mandatory water conservation programs. Exceptions to this rule will be considered when surface water cannot realistically be introduced within a given time frame. Additional subsidence may occur in these areas before treatment and distribution facilities are completed.

Thus far, the plan has been quite successful in the four coastal areas where HGCSD efforts were initially concentrated. Since the HGCSD first began regulating in 1976 total groundwater pumpage for the district has decreased from 457 million gallons a day to 366 million gallons a day in 1988 (see Tables 12-1 and 12-2). The bay area and the Houston Ship Channel are reported to be "under control," and the water level in the aquifer has dramatically increased since 1977. The four areas highlighted in Figure 12-1 reduced their groundwater withdrawal from 1977 to 1989 as follows: Area 1 went from 140 million gallons a day to 20 million gallons a day; Area 2 went from 110 million gallons a day to 60 million gallons a day; Area 5 went from 10 million gallons a day to 20 million gallons a day; Area 8 remained steady at 40 million gallons a day. Apparently Area 1

converted almost entirely to surface water, while Area 2 has begun the projects to allow conversion to surface water.

Table 12-1
Ground Water Pumpage in Harris and Galveston Counties
(million gallons per day)

Source	1976	1980	1985	1990
Public supply	255	331	328	316
Industrial	151	50	32	28
Agricultural	52	51	25	26
Total	458	432	384	369

Table 12-2
Surface Water Use in Harris and Galveston Counties
(million gallons per day)

Source	1976	1980	1985	1990
Trinity (CWA)	4	143	144	177
San Jacinto	212	223	229	228
Brazos	66	65	66	75
Total	281	431	439	480

Source: (both tables): Texas Water Development Board, cited in Environmental Institute, A Socioeconomic Characterization of the Galveston Bay System, Clear Lake, August 1991, p. 5-11.

The Permitting Process

To drill or operate a well in Harris or Galveston counties, it is necessary to obtain a permit, unless the well is less than five inches in diameter. Applicants must submit a plan for improving water accountability for the well. Permittees must agree to convert to surface water within a certain time period and cost framework. When considering permit allocations for water suppliers, the board requires an audit of per capita water use and considers the percentage of water that will be lost through the system before setting the parameters of the permit. These plans are submitted to the board for approval and a public hearing is conducted for each application before issuing the permit. The fee paid by the permittee is based on the annual allocation of groundwater authorized by the board. Subsequent to issuance, and as a pre-condition for annual renewal, the HGCSD monitors the permittee to ensure the permit parameters are met.

The district may deny permits, limit groundwater withdrawals, and amend or revoke permits. They do not, however, have the right to prohibit a private land owner from extracting groundwater from his/her own land. They can regulate the extraction but they cannot prohibit it. For this reason, a permit has never

been denied except for failure to pay fees. The following factors are considered when setting the parameters for each permit:

- the intent of the law;
-objectives and requirements of the Action Plan including an equitable distribution of groundwater;
- the quality, quantity, availability and price of surface water;
- the economic impact of permit terms on the applicant;
- the relative effect on subsidence; and
- an equitable distribution of available groundwater.

Surface Water Conversion. Harris and Galveston Counties' surface water system consists of a combination of rivers, man-made lakes and reservoirs, treatment facilities, and adjoining transmission canals to deliver the water. Through the development of surface water facilities, the two counties reduced their dependence on groundwater from 62 percent when legislation was first enacted in 1976 to 44 percent in 1989. The reduction was achieved despite a 96 million gallons per day overall rise in total water demand during the same years. Decreased groundwater pumpage is primarily due to surface water conversion and conservation efforts. Successful surface water conversion projects made the difference. Surface water is primarily sourced from the San Jacinto, Trinity, and Brazos rivers which now supply 56 percent of the water in these counties.

These results are not, however, uniform across the two counties. Successful results in those areas targeted by HGCSD's initial efforts have been offset by a lack of improvement in untargeted areas. This outcome underscores the importance of plan implementation. Because the HGCSD is not authorized to exercise any administrative penalties, educational efforts played a large role in the success of the targeted areas. Studies of the two aquifers supplying the region show that in targeted areas east of Houston, aquifer levels rose substantially after 1977 (180 feet for Chicot and 140 feet for the Evangeline) while they decreased in untargeted areas west of Houston (80 feet for Chicot and 140 feet for Evangeline).

Regional Water Supply District.

HGCSD is exploring the idea of becoming a district water supplier, although the law currently prohibits engaging in such a business. This issue may soon be re-examined as the agency turns its attention to the northern and western areas of the district where subsidence is still occurring. These areas are more arid, are largely residential, and do not have access to the surface waters on the far side of the district.

Because treatment plants and transmission lines are so expensive to construct, HGCSD believes the process of halting subsidence in these areas would be greatly accelerated with one regional supplier. This supplier would most likely be the City of Houston, since the problem requires building a large treatment plant on the west side of Lake Houston with transmission lines going to the northwest residential area. The City of Houston has the water rights to Lake Houston but

has thus far expressed a reluctance to be the sole capital supplier for such an expensive undertaking.

Analysis of Implementation

Subsidence in the Houston/Galveston area is expressed in terms of feet. The HGCSD has several different means of securing data for this purpose. Subsidence rate data is provided by 11 monitors dispersed throughout the district. These monitors record subsidence on a continual basis. Releveling is a process using differences in elevation between one measurement and another to determine amounts of subsidence. A type of electronic leveling uses satellite technology to determine elevations. With satellites the HGCSD can monitor changes in elevation from numerous benchmarks throughout the district. Finally, changes in aquifer water level are measured each year.

Subsidence monitors east of Houston show little or no subsidence while those west of Houston show continuing subsidence of approximately 1.5 inches a year. These data indicate that continued regulatory efforts are necessary to reduce potential subsidence. Other data indicate that regulation of large users targeted by initial action plans has been successful. Whereas in 1976, 56 percent of groundwater was used by the public, 11 percent for irrigation, and 33 percent for industrial purposes, groundwater use percentages in 1989 were 85 percent, 7 percent, and 8 percent for the public, irrigation and industrial use respectively. As already discussed, this success ratio is largely due to surface water conversion projects. In addition, accountability studies required from permit applicants have lead to increased use of customer meters, meters on public facilities, the recalibration and repair of meters, and leak detection surveys.

Given the fact that groundwater is still much cheaper than surface water and that the HGCSD is not altogether free to deny permits, has no administrative means of enforcing those permits, and has only a handful of staff to monitor meters and other compliance mechanisms (there are only 17 employees for the entire district office), why does this program work?

There are three main reasons. First, it works because of the penalties associated with litigation. While the HGCSD is not authorized to assess administrative penalties, it can file lawsuits through the Texas Attorney General's Office. These cases usually end up settling out of court because the criminal penalties associated with violating well permit laws are so stringent. The HGCSD can cap the well, or assess a losing defendant a minimum fine of $50 for each day that the defendant was found to be in violation of the law. Second, it works because the large users targeted by the plan know the consequences of subsidence, and realize that when they rely on wells they are pumping groundwater out from under themselves.

The third reason the plan works is public outreach and education coupled with cooperation and a willingness on the agency's part to assist permittees in meeting the terms of their permits. Public awareness and cooperation appear to be a very important element in the success of this particular program. The HGCSD hosts

water conservation seminars and a water conservation booth at various public events. The agency holds a Groundwater Public Hearing every year. The agency also promotes voluntary conservation measures through a quarterly newsletter and through speaking presentations.

In addition, the HGCSD assists permittees in making the conversion to surface water by helping them in negotiations to secure loans from the Texas Water Development Board which is responsible for helping local governments finance their water supply systems. The HGCSD works with water utilities and agricultural users to promote the most efficient use of water, and cooperates with cities to help them work toward conversion to surface water.

EVALUATION

The easy steps to reduce subsidence have been taken. HGCSD attacked the most visible problems, which occurred in areas where people live close enough together to make use of surface water economically feasible. Further progress in reducing subsidence can only occur if it is reduced in areas where more dispersed individuals live—individuals for whom the immediate costs of using surface water may well be significantly higher than the benefits of reducing subsidence.

Continued subsidence in the northwest area of the district is the problem most in need of immediate attention. Solutions will not be easy. HGCSD is implementing changes to regulatory requirements that will require groundwater users in this area to convert to surface water by the year 2002 instead of the originally envisioned deadline of 2010. However, it will be difficult to require this conversion without somehow supplying the necessary surface water. Moreover, residential well owners do not have the same incentives to cooperate with HGCSD as the industrial well owners in the southeast area. Many of the residential owners do not even have to be permitted, and residential developers see no point in paying for huge treatment plants and transmission projects when they can sink a well to service their new subdivisions.

Several wells in the problem area of the northwest have water quality problems due to natural factors such as radon gas and heavy iron concentrations. Yet these problems are not widespread enough to encourage well users to convert to surface water on a large scale basis. Moreover, such problems can be easily remedied by digging a deeper well that bypasses the problem strata, or simply digging a new well at a nearby site. Perhaps the most viable solution would be a partnership between the City of Houston and the utility districts in the area to be supplied. This is an arrangement that has worked very well in the southeast part of the district. The larger the treatment plant, the greater the economies of scale in delivering services. Unlike a contract, partial ownership of the plant also guarantees a perpetual right to water.

BAY AND COASTAL EROSION

Comparative shoreline data indicates that 78 percent of the shoreline in the Galveston Bay system eroded to some extent between the 1850s and 1982. The average annual erosion rate was 2.2 feet for a total net loss of 8,000 acres (Paine and Morton, 1986, p. 165). Erosion threatens residential and industrial areas as well as plant and wildlife communities. Both natural and human factors contribute to erosion. Natural causes include normal wave activity, storms, and relative sea-level rise. Human causes include increased wave activity from commercial ships, fishing boats, recreational boats, and sedimentation reduction from tributary impoundments. Dredging in channels, waterways, and for marinas also contributes to erosion problems. Table 12-3 shows the numerous boats registered in the four county area surrounding the bay. These figures do not include foreign commercial tankers and barges, and are thus only a partial representation of the many boats traversing the bay on a daily basis. It is especially important to note that many of the largest vessels, which cause the most severe wakes and contribute most heavily to erosion, are not registered in the bay area, or even in the United States.

Table 12-3
Boat Registrations in Brazoria, Chambers, Galveston, and Harris Counties (as of December 31)

Registration Type	1975	1980	1985	1990
Pleasure boat	96,300	103,477	102,969	100,413
Livery	254	161	221	144
Commercial fishing	397	409	636	556
Other commercial	516	370	372	452
Commercial, no fee	426	560	337	160
Political	130	182	215	240
Total	98,023	105,159	104,750	101,965

Source: Adapted from Texas Department of Parks and Wildlife, Boat Registration Office, cited in Environmental Institute, A Socioeconomic Characterization of the Galveston Bay System, Clear Lake, August 1991, p. 5-5-6.

Inland improvement projects such as damming rivers for hydroelectric power, water supply projects, and lining creek bottoms with concrete to prevent flooding also promote erosion by hoarding sediment that would normally be deposited into the bay through freshwater inflow. Such sediment provides a crucial replenishment to the bay's shoreline and its wetlands. Marshes constitute 61 percent of the Galveston Bay shoreline, and are particularly common in East and West Bays. When a regular flow of sediment is impeded from reaching the bay, natural sea level rise and subsidence (typically between .5 and 1.0 inches per year) can drastically affect marshlands, causing them to migrate inland, or causing outright loss of wetlands. Marshlands can only migrate inland when the

contiguous low fastlands have not yet been developed, a condition that is rapidly becoming rare in Galveston Bay. Also, subsidence is exacerbating the marsh loss problem. The slightest subsidence can further exacerbate this problem.

Coastal erosion is also a problem in the bay area and is causing the beach to disappear at a rate of 33 feet per year. Sargent Beach has suffered the most severe shoreline erosion. Many homes and beachfront property have been unsalvageable and there only 600 feet of land separate the Gulf Intracoastal Waterway from the open Gulf of Mexico. This area is especially sensitive because any more serious disruption could halt ship and barge traffic which carries an annual average of 17 to 19 million tons of goods valued at $20 million. Although not in the study area, the example of Jefferson County is also instructive: Highway No. 87, right on the coast, has been closed due to the eroded shoreline upon which it depended. The closing of this highway cut tourism to Sea Rim State Park by 50 percent. Seafood restaurants in Sabine Pass that catered heavily to tourists are foundering. Similarly, Galveston's seawall at West Beach, a major tourist attraction, is threatened because of erosion.

Public beach use tramples and destroys the vegetation that stabilizes sand. This makes the beach and its dunes more susceptible to wind and water erosion, thus inhibiting their recovery from storms. Coastal sand dunes help protect inland property from erosion and flooding by absorbing the force of high waves, and wind. When storm waves exceed the low points along a dune ridge, water overflows these low points and washes down the landward side of the dunes, raising the sea level in the bay and affecting the balance of the bay's salinity. As these washover areas deepen and widen, larger volumes of water spill across the dune line and flow farther inland. An accumulation of windblown sand may also develop in marshlands and grass flats, thus disturbing the natural balance in these fragile ecosystems.

Ship wake is another important cause of erosion. There are no speed limits for any of the ship channels, and no signs posted advising lower speeds. Every master is responsible for his own wake and is liable for any damage caused by his wake, but there are no administrative penalties for enforcing this. An occasional lawsuit occurs when someone's boat or other property has been damaged by a wake, but not often enough to act as a deterrent in the absence of a regulatory wake control program.

Federal rules concerning dune protection are outlined in the Federal Manual for Identifying and Delineating Jurisdictional Wetlands. Anyone undertaking dune protection and improvement projects in wetlands covered by this manual must first get a permit from the federal government. The Sea Grant Program and the Soil Conservation Service are engaged in bay erosion research. At the moment, there are no state rules addressing bay shore erosion. Senate Bill 1053 (passed in the 1991-92 legislative session) made GLO the lead state agency for coordinating response to both bay and beach erosion. However, this bill did not specifically authorize GLO to draft rules regarding bay erosion. The bill merely refers to the development and use of disease resistant seagrass to mitigate bay shore erosion. State officials recognize the need to develop policy and regulations regarding bay

shore erosion, and will most likely rewrite existing Submerged Lands Rules to address bay shore problems. There has also been discussion on incorporating bay shore erosion concerns into policies affecting freshwater inflow. It is not clear which agency has the authority to write such rules, but TWC would more than likely take the lead in such an effort.

With regard to coastal erosion, the Dune Protection Act requires counties bordering the Gulf of Mexico to establish a dune protection line (up to 1000 feet landward of the mean high tide line) on the gulf shoreline. This may also be carried out by municipalities. The Texas Coastal Management Plan (lead by the GLO) recommends beach traffic lanes, off-beach parking, and dune walkovers as ways to minimize vehicle and pedestrian impact on dunes as well as dune vegetation and restoration. In addition, the Texas Natural Resources Code regulates the removal of sand, marl, gravel and shell from islands, peninsulas, and land within 1500 feet of mainland public beaches outside corporate limits. A permit must be obtained from the county commissioners court for the excavation of any of these materials unless the material is to be moved by a landowner or with a landowner's consent from one location to another on the same piece of property. This is regulated by TPWD in all cases except for dredging and navigation activities permitted by the federal and state governments.

The Open Beaches Act is a possible impediment to state efforts to prevent coastal erosion. The act guarantees the public's right of free and unrestricted access to the "public beach" which extends from the line of mean low tide to the line of permanent vegetation on the shoreline bordering the Gulf of Mexico. As such, it is unlawful to prevent or impede access to or use of the public beach by erecting barriers or by erecting signs declaring a beach closed to the public. Amendments to the Texas Natural Resources Code passed in 1991 require each coastal local government to adopt a plan for preserving and enhancing access to and use of public beaches within its jurisdiction.

EVALUATION

Clearly, policies and rules (outside of subsidence) aimed at arresting bay shore erosion have not been a priority in the state of Texas. This is no doubt due in part to the amorphous nature and magnitude of the problem. However, there are several measures that can be taken to slow the rate of erosion. Policymakers should begin by acknowledging that erosion problems are interrelated with other policy areas, and that what may be good for the shore, or good for the river, or good for the channel is not always good for the bay. An effort should be made to introduce erosion concerns into such programs. A mitigation program should also be considered for developments that steal sediment from the bay and its habitat. This could easily be tied in with the wetlands mitigation program, and could be based on the premise that the state's public interest in the beach gives it a right to intervene even if the eroding beach is privately owned and its owner takes no action, or even for inland projects that affect the beach. Privately owned marshlands, for example, produce resources like fish and waterfowl which belong to the public. Consideration should also be given to a boat ship wake management plan that restricts boat speed and boat traffic near areas sensitive to

erosion. Such a program would require a baywide shoreline erosion ranking plan that identifies the areas to be protected. Overall, bayshore erosion is poorly documented and essentially unregulated, especially in contrast to coastal erosion. A program to reduce bayshore erosion is a high priority for Galveston Bay.

SUMMARY EVALUATION: **SUBSIDENCE AND EROSION**

1. Problem. Subsidence: Removal of water from clay soils causes subsidence. Water encroaches on shore and removes wetlands habitat. Bay expected to be two hundred square miles larger by 2010.
Erosion: Bay shoreline erodes from boat wakes, construction, and inland projects affecting sediment replenishment.

2. Authority. Subsidence. Subsidence is regulated through state laws which limit groundwater removal and require conversion to surface water.
Erosion. There are no federal or state laws specific to bay shore erosion.

3. Capacity. Subsidence. High for areas with access to surface water; lower for those without access. Funding has been sufficient for purchasing high technology equipment for monitoring subsidence and aquifer levels.
Erosion. Low because it is not perceived as a priority and no policy framework is in place to address problem.

4. Policy. Subsidence. Permitting process implements regulatory goals. Permittees must improve water accountability and convert to surface water within a certain time period.
Erosion. State policy appears most likely to emerge in the context of wetlands erosion and submerged lands.

5. Technical and environmental results. Subsidence. Total groundwater dependence dropped to 44%. Little or no subsidence east of Houston; continued subsidence west of Houston.
Erosion. Continuing.

6. Barriers and problems. Subsidence. Now that the problem is under control in more densely populated areas, attention must be turned to other areas where solutions are more expensive and each individual makes a smaller contribution to the whole problem/solution.
Erosion. Problem remains largely unidentified and amorphous.

7. Recommendations. Subsidence. Utility districts and developers west of Houston should consider a partnership with the City of Houston that will allow them to construct a large surface water treatment facility on Lake Houston. HGCSD could assist in negotiations.
Erosion. Measure the problem through shoreline mapping that prioritizes areas to be protected. Efforts to arrest bay shore erosion should be more closely tied to state programs addressing coastal erosion since the two are interrelated. Launch a public awareness campaign in tandem with a program that regulates boat speeds and boat traffic in areas sensitive to erosion. Improvement projects on freshwater tributaries and rivers should be reviewed for possible erosion effects and possible mitigation. Limit reservoirs, diversions, and channelization projects, which often exacerbate erosion.

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